METABOLIC SYNDROME IN RELATION TO BODY COMPOSITION AND LIFESTYLE ADAPTATION AMONG SELECTED ADULTS RESIDING IN BENGALURU

Ph.D. Synopsis submitted in partial fulfilment of the requirement for the Degree of Doctor of Philosophy in Food Science and Nutrition

Submitted By

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a) Title of the Thesis:

Metabolic syndrome in relation to body composition and lifestyle adaptation among selected adults residing in Bengaluru

b) Brief Description on the state of the art of the research topic:

Non-Communicable Diseases (NCD) can be classified into two major headings. The first group consists of four main types of diseases such as cardiovascular diseases, cancer, diabetes mellitus and chronic respiratory diseases. The second group comprises of hypertension, dyslipidaemia, obesity, metabolic syndrome, rheumatoid arthritis, cerebrovascular disease, osteopenia/osteoporosis, degenerative disk disease, sarcopenia and frailty, depression, cognitive impairment and neurodegenerative disease. The 2030 Agenda for Sustainable Development recognizes NCDs as a major challenge for sustainable development. Available data also indicate that premature deaths from non-communicable diseases in India contribute substantially to this loss of productivity. In fact, deaths due to cardiovascular diseases alone gives India the “highest loss in potentially productive years of life” out of all countries in the world (Reddy *et al*., 2005).

Metabolic syndrome is a cluster of any three conditions from increased blood pressure, high blood sugar, excess body fat around the waist, and abnormal cholesterol or triglyceride levels (NCEP ATP-III, 2002; Grundy *et al.,* 2005 and Alberti *et al.,* 2005). This leads to increasing the risk of heart disease, stroke and cancers. Rajendran *et al.,* (2021) in their study showed that metabolic syndrome is highly prevalent (72.6% as per modified ATP III) among the out-patients attending cardiology/ diabetology outpatient department of tertiary care hospital. In a cross-sectional based study conducted in the rural area of Kancheepuram district; the prevalence of metabolic syndrome was found to be 16.7% (Selvaraj *et al.,* 2019). Having just one of these conditions doesn't indicate the presence of metabolic syndrome. However, any of these conditions can increase the risk of serious disease which is further increased as the number of disease conditions increase. Research also proves that aggressive lifestyle changes can delay or even prevent the development of serious health problems associated with metabolic syndrome.

Therefore, aiming at primary prevention to reduce the epidemic state is important (Ranasinghe *et al.,* 2017).

Metabolic syndrome is closely linked to overweight or obesity and physical inactivity. It's also linked to a condition called insulin resistance. Insulin is a hormone made by the pancreas that helps sugar enter the cells to be used as fuel. Normally, the digestive system breaks down the food consumed glucose. In people with insulin resistance, since cells don't respond to insulin and glucose can't enter the cells as easily, the glucose levels in the blood rise despite the body's attempt to control it by churning out more and more insulin. The lifestyle habits of tobacco use, smoking or alcohol consumption can also increase the risk of metabolic syndrome (Slagter *et al.,* 2014). The overweight/obesity epidemic is a major concern for chronic disease prevention and health across the community around the world. Urbanization, mechanical transport, economic growth and industrialization has increased sedentary lifestyle, and a nutritional transition to processed foods and high calorie diets over the last 3 decades has doubled the prevalence of obesity. Indians are at a greater risk of developing metabolic syndrome, because of the increasing prevalence of obesity in the nation. Treatment and management of metabolic syndrome usually involve lifestyle changes, such as adopting a balanced and nutritious diet, engaging in regular physical activity, and losing weight if necessary (WHO, 2010; Dalle *et al.,* 2010).

c) Definition of the problem:

In India, diabetes mellitus and obesity are alarmingly increasing, both of which are components of metabolic syndrome (Saklayen 2018) as defined by the NCEP ATP III (2002) and updated in 2005 by the American Heart Association/National Heart, Lung, and Blood Institute (Grundy *et al.,* 2005). However, the curative measures for metabolic syndrome are more present than the preventive measures. Additionally, individual factors are often prioritized during treatment approaches; whereas a cumulative effort for addressing metabolic syndrome parameters in total is essential. While targeting weight management, it also becomes essential that body composition should be considered instead of just calculating body mass index or waist-to-hip ratios, along with

regularly reviewed counselling sessions on lifestyle adaptation. Therefore, the current study was conducted to depict the relationship between metabolic syndrome and body composition parameters with intervention of the lifestyle education.

d) Objectives and Scope of Research Work

(a) Primary Objectives: To

- Assess the prevalence of metabolic syndrome in the selected adults residing in Bengaluru
- Assess the body composition parameters of the enrolled metabolic syndrome sub-sampled research subjects
- Assess the relation between metabolic syndrome, body composition, and lifestyle adaptations in the enrolled sub-sampled research subjects
- Develop and educate on a healthy lifestyle about diet, exercise, and social habits of the subjects to prevent/ cure metabolic syndrome
- Assess the Knowledge Attitude and Practice of the subjects regarding metabolic syndrome, body composition, and lifestyle

(b) Secondary Objectives: To

- Emphasize the importance of Body composition parameters to prevent non-communicable diseases
- Validate the InBody 770 BIA (Body Impedance Analysis) Vs DEXA (Dual Energy X-ray Absorptiometry method used in the current study is reliable in assessing Body Composition Analysis.

e) Scope of the research study:

Non-communicable diseases are rising in the current scenario. Metabolic syndrome is one among the non-communicable diseases. With a healthy lifestyle of diet, exercise, and good social habits the metabolic syndrome can be prevented or the individual parameters leading to metabolic syndrome can be regulated to normal levels. The importance of assessing the body composition parameters beyond the general assessment of weight and body mass index has to be imparted to lead a healthy life which is very important for a sustainable community.

f) Methodology:

The study design is cross sectional and a longitudinal study. The subjects were selected from Sakra world Hospital Bengaluru. A total of 2250 research subjects were screened from among those visiting preventive health check- up in Sakra World Hospital in the period in which the study was carried out was July 2021 to February 2023.

The ethical approval from the Institutional Human Ethics Committee of Avinashilingam Institute for Home Science and Higher Education for Women. Coimbatore was obtained (AUW/IHEC17-18/FSN/50). Later the research study was proposed and clearance was obtained from Sakra World Hospital Institutional Ethics committee (IEC/SWH/CN/26619) to select the research subjects and collect the data. The six phased study was also registered in Clinical Trial Registry of India: CTRI/2021/07/035254.

In the first phase the selection of subjects and development of research tools to collect the data, developing and standardising the counselling materials and validating the Inbody 770; bio electrical impedance analysis was carried out according to previous research conducted by (Ozhan *et al.,* 2012; Bosy-Westphal, 2013; Mahmood Aldobali *et al.,* 2022). There were a total of 2250 who visited preventive health check- up in Sakra World Hospital. By considering the inclusion and exclusion criteria 1359 subjects were enrolled into the research study after obtaining consent from the subjects.

In the second phase, socio- economic information of age, education, social economic scale, family structure, marital status from the research subjects was recorded. The subjects between 20–50-year-old males and females were enrolled into the study after considering the inclusion and exclusion criteria.

In the third phase, the research subjects were assessed for the presence of metabolic syndrome and anthropometric measurements like height, weight, waist circumference, and hip circumference were recorded and body mass index and waist-hip ratios were calculated. Biochemical parameters like fasting blood sugar, triglycerides, HDL cholesterol and blood pressure measurements were also noted. Lifestyle habits pertaining to dietary preferences, physical activity levels, exercise, smoking and alcohol

habits of the research subjects were collected. By using NCEP ATP III 2002 and updated in 2005 by the American Heart Association/National Heart, Lung, and Blood Institute (Grundy *et al.,* 2005) criteria, the prevalence of metabolic syndrome among the research subjects was analysed.

In the fourth phase after following the definition of metabolic syndrome and obtaining informed consent, 180 (n) metabolic syndrome patients were found among 1359 (N). By using Daniel's (1999) formula, the sample size based on the prevalence of metabolic syndrome (15-25%) (Bhalwar, 2020) was calculated to be 153. Initially 155 subjects gave consent but following 5 drop-outs, 150 subjects were considered for the continuation study. Body composition analysis was carried out for these metabolic syndrome subjects and Knowledge, Attitude and Practices (KAP) of the research participants was collected through a questionnaire (Yvette *et al.,* 2014; Swami *et al.,* 2021). For the subsequent three months, the lifestyle intervention pertaining to the diet, exercise, physical activity level and encouragement for the smoking and alcohol cessation (if prevalent) was carried out. Every 15th day; an on-call consultation was done and the information regarding life style was re-iterated to the subjects, where they clarified their doubts. Meanwhile, considering the KAP of the research subjects, a few more education materials in the form of information sheets and PowerPoint presentations on aspects related to diet, exercise, and stress management were vetted by experts and shared as soft copies/hard copies with the subjects.

In the fifth phase i.e., in the 4th month, they were asked to re-visit the hospital to re-assess the study parameters. The impact of intervention of lifestyle counselling among the metabolic syndrome was recorded and analysed. This included the impact of intervention on anthropometric measures and body composition analysis parameters, on calorie intake, physical activity level, exercise, smoking and alcohol habits, on metabolic syndrome criteria, and the impact of lifestyle counselling on KAP in the research subjects.

In the final i.e., sixth phase the data collected was statistically analysed and interpreted. To look at the prevalence of metabolic syndrome, the significance/relation between metabolic syndrome, body composition, and lifestyle adaptations the statistical

analysis and interpretations were carried out among the research subjects (N=1359) and metabolic syndrome subjects (n=150) from the pre- and post-intervention data. Data was analysed using R software version 4.3.1 (R Core Team, Vienna, Austria, 2021).

Descriptive statistics were carried out for categorical data by presenting frequencies and percentages. Continuous measured data were described using mean, standard deviation or median and interquartile range based on their distribution. The normal distribution assumption was assessed using the Shapiro-Wilk test. As part of the intervention study; the impact of health style modification was assessed by comparing the pre and post- calories consumed, exercise, metabolic syndrome and body composition analysis parameters. Changes in measured parameters were evaluated using the paired sample T-test or Wilcoxon signed-rank test based on the parameter distribution. Changes in levels of categorical parameters were checked using the Stuart-Maxwell marginal homogeneity test. Social, diet, bio-chemical, exercise, and Body composition analysis parameters were compared between those who recovered from metabolic syndrome and those who did not. The comparison was conducted using independent sample T-tests or Mann-Whitney U tests for continuous measured parameters based on the distribution, and using the Chi-Square test or Fisher's exact test for categorical observations based on the expected frequency after checking the normality assumption. Univariate and multivariate logistic regression analyses were carried out to study the unadjusted and adjusted impact of risk factors on metabolic syndrome. The Odds ratio was reported as the measure of association between the risk factors and metabolic syndrome. Parameters significant at a 5% level of significance were included in the adjusted regression model.

In the Knowledge Attitude and Practice study, the levels of knowledge, attitude, and practices on lifestyle modification was recorded before and after the intervention. The change in the KAP levels were tested using the Stuart-Maxwell marginal homogeneity test. P-values were considered significant at a 5% level or lower for all comparisons.

g) The salient findings of the study are as follows:

- Reliability and validation of DEXA with InBody 770 was tested (n=20; Bujang, 2018) and statistically analysed. The Cronbach's alpha obtained for DEXA and

InBody 770 body composition analysis were 0.821 and 0.818 respectively. This states that the InBody 770 body composition analysis equipment is validated for performing body composition analysis in comparison with DEXA scan body composition analysis.

- The participants were categorized based on age and sex and presented. Age of 20-50 years, that is 1359 were included in the study comprised of 60.9% male and 39.1% female subjects. In the age group of 21-30 years, there were 15.9% in total among which 12.6% were males and 21.2% were females. In the age group of 31-40 years, there were 44.2% in total among which 44% were males and 44.4% were females. In the age-group of 41-50 years, there were 39.9% in total among which 43.4% were males and 34.4% were females.
- The educational status of the subjects was classified as per the ministry of human resource development, Department of school education & literacy statistics division- educational statistics at a glance report (2018). In the current study, a majority had completed graduation (53.9%) whereas technical/diploma/certificate courses were done by 26%. Intermediate occupations were done by 54.7% of subjects and there were 27.2% of small employers/own account workers. In the present study, the majority (88.1%) belonged to lower middle-income group. Modified Kuppuswamy socio- economic scale (Kumar *et. al.,* 2022) was used in the current study. In the current study there were no subjects belonging to lower socio-economic state. Majority of the subjects belonged to nuclear families (79.8%), 67.5% were married while 30.5% were unmarried subjects.
- The mean Body Mass Index (BMI) of the entire subjects was 26.6 ± 4.6 kg/m^2 the mean BMI of males was 26.6 ± 4.2 kg/m^2 and females mean BMI was 26.7 ± 5.2 kg/m^2. The mean waist circumference among the subjects was found to be higher than the standards (IDF, 2021). In males it was 92.5 ± 8.1 cm and females had waist circumference of 88.7 ± 10.3 cm. The hip circumference was measured for the entire research subjects and the mean was 106.8 ± 13.6 cm. The mean hip circumference of males was 108.1 ± 12.3 cm and females were 104.9 ± 15.2 cm. 0.86 ± 0.1 was the mean waist-to-hip ratio found among the subjects.

- The alcohol and smoking habits as revealed among research subjects in the current study showed that 1132 (83.3%) never consumed alcohol out of which 665 (80.4%) were males and 467 (87.8%) were females never consumed alcohol.
- The prevalence of metabolic syndrome in the currently enrolled subjects was 13.2%. The enrolled males had a prevalence of 15.6% as against the 9.6% observed in females.
- Four metabolic syndrome criteria were present in 5.7% of the subjects (78 subjects – 58 males and 20 females). All the five metabolic syndrome criteria were observed in 2.1% of the subjects (28 subjects – 19 males and 9 females). However, two criteria were observed in 50.9% subjects (692 subjects, 348 males 344 females). 26% (354 subjects) had one of the metabolic syndrome criteria while 133 subjects were not having any of the metabolic syndrome criteria.
- Low levels of high density lipoproteins was observed in 765 subjects (56.3%), high waist circumference was observed in 748 subjects (55%), high triglycerides was observed in 388 subjects (28.6%). High fasting blood sugar values were seen in 367 (27%). Systolic blood pressure was high in 151 (11.1%) and diastolic blood pressure was high in 47 (3.5%) subjects. Overall, 180 subjects had metabolic syndrome of which 129 males and 51 were females.
- The exercise routine, physical activity level, smoking habit, alcohol consumption, calories consumed per day, basal metabolic rate, total energy expenditure were statistically significant at <0.001 among both the groups.
- The waist circumference, weight, body mass index and waist- hip ratio were statistically significant at <0.001 among both the groups. But hip circumference had no statistical significance.
- The waist circumference, fasting blood sugars, triglycerides, HDL cholesterol, diastolic blood pressure and systolic blood pressure were statistically significant at <0.001 in subjects with and without metabolic syndrome.
- Preventive health check-up patients of 1359 were enrolled into the research study. 217 subjects (16%) were from 21-30 years, 600 subjects (44.2%) were from 31-40 years, 542 subjects (39.9%) were from 41-50 years. 733 subjects (39.9%) were graduates, 743 subjects (54.7%) had intermediate occupations.

1197 (88.1%) belonged to the lower middle-income group, 1147 subjects (84.4%) were a part of nuclear families. 414 subjects (30.5%) were unmarried and 918 subjects (67.5%) were married.

- Lifestyle habits when monitored revealed that more than 60% of them were consuming >2000kcal diet; 16% were alcoholic; 5% had smoking habits. Exercise was not done by 75% and sedentary physical activity was observed among 75% of subjects. Researchers have stated that obesity and a sedentary lifestyle are interrelated and co-exist.
- Waist Circumference had a high correlation with body composition analysis parameters of TBW, protein, mineral, BF%, SMM and biochemical parameters.
- Impact of lifestyle education therapy was highly significant on metabolic Syndrome & Body Composition (Dalle *et al.,* 2010)
- Lifestyle education increased the knowledge about diet and exercise by 20%; The knowledge about metabolic syndrome and diet habits increased by 40%. The attitude of participants towards healthy lifestyle also increased by 16% while the practicing of the healthy life style increased by 40%.
- The mean age, height and weight of the research subjects were 40 ± 5.9 years, 167.3 ± 9.3 cm and 80.9 ± 15.1 kg respectively. There were 3 (2%) who had undergone primary schooling, while secondary schooling was done by 17 (11.3%), and 55 (36.7%) did technical or diploma or certificate courses and 75 (50%) subjects were graduates. 80 (53.3%) subjects were small employers and own account workers, 39 (26%) of them had routine occupations, 17 (11.3%) subjects had lower supervisory and technical occupations 2 (1.3%) of them were in high managerial administrator and professional occupations.

- A majority of 92 (61.3%) belonged to lower-middle socioeconomic class, 32 (21.3%) belonged to upper-lower socio-economic class and 26 (17.3%) were of upper middle socio-economic class. 93 subjects (62%) belonged to nuclear family while 26 subjects (17.3%) were single members. 22 subjects (14.7%) were in joint families and 9 subjects (6%) belonged to extended families. Married subjects were 114 (76%), unmarried were 30 (20%) subjects while 3 (2%) divorced and another 3 (2%) were widowed.

- A majority of 94% (141) subjects had come for preventive health checkup without any prior medical history. There were some mothers (39.3%) and fathers (62%) of subjects who had no familial history of metabolic diseases and in the current research study, family history had no statistical significance with presence of metabolic syndrome parameters.
- Most of the subjects (64.7%) were having predominantly vegetarians and at times were consuming non vegetarian food. Simultaneously, the caloric intake was high in this research group from the fats and oils and refined cereals.
- Exercise was not done by 25 (21.6%) males. Around 89 (76.7%) male and 33 (97.1%) female subjects stopped exercising for more than three months.
- When the metabolic syndrome parameters were scrutinized after grouping for age, it was found that waist circumference (cm) was highest among females aged 41-50 years (106.7 ± 13.6) and 21-30 years (104.4 ± 11.7). Among males the waist circumference was highest among 31-40 years (103.6 ± 12.9) compared to the other age groups. The fasting blood sugar values (mg/dl) were higher in males of 41-50 years (151.2 ± 62) and females of 41-50 years (146.4 ± 71 .9). The males in 21–30-year group and 31-40-year group had higher FBS than females of the same age group. The triglycerides were very high among 21-30-year-old males (306.2 ± 199.1) and 31-40-year old males (282.3 ± 229.1). The HDL cholesterol was low among 21-30 year old males (34.5 ± 4.2) and females (31.2 ± 4 .3).
- The body composition parameters as assessed indicated that the total body water in males was 39.1 ± 5.6 while in females it was 28.9 ± 4.3. The protein was higher in males (10.5 ± 1.6) compared to females (7.7 ± 1.1). The mineral content was higher in males (3.7 ± 0.6) compared to females (2.7 ± 0.4). The body fat mass was higher in females (37.7 ± 10.6) compared to males (28.7 ± 9.4). The weight of both sexes was not different statistically. The skeletal muscle mass of males (29.8 ± 4.6) was higher than that of females (21.3 ± 3.4). The body fat percent of females (48.3 ± 4.4) was higher than the males (34.4 ± 6). As the protein, skeletal muscle mass, and mineral content were high in males as they had higher InBody scores than females. The visceral fat area of females (190.8 ± 39 cm^2) was higher

compared to males (135.6 ± 47.9 cm^2). The degree of obesity was higher in females (126.5 ± 63.3) than males (100.3 ± 55). The whole-body phase angle was good in males (5.9 ± 0.6) when compared to females (5.2 ± 0.5).

- In males and females, the body composition analysis parameters were analysed to reveal that the total body water, protein, minerals, body fat mass, skeletal muscle mass, body fat percentage, visceral fat area, basal metabolic rate and whole-body phase angle were statistically significant at $p<0.001$.
- The basal metabolic rate of 21-30-year-old males (1553.8 ± 142.5) was the highest while among females, it was the 41-50 year olds who had a high basal metabolic rate of 1308.6 ± 173.1 kcals.
- Assessing the KAP scores revealed that 73.3% had good knowledge scores regarding healthy diets for general nutrition, while 62.6% had good knowledge scores regarding exercise and weight loss. 26% had good knowledge scores regarding body composition and 50.7% had good knowledge scores regarding metabolic syndrome and lifestyle to be followed. Positive attitude towards lifestyle modification was observed in 56% of subjects and good lifestyle practices were observed in 40% of subjects.
- The pre and post mean values of anthropometric measurements were statistically analysed. Waist circumference and waist-to-hip ratio had highly significant correlations at <0.001.
- The pre- and post- mean values of body composition analysis values were statistically analysed and among the various measures of body composition analysis, the body fat mass, body fat percentage. In-body score, visceral fat area, weight to control, fat to control and obesity degree were all statistically significant at <0.001.
- The average calories consumed pre- and post-intervention were statistically significant at $p < 0.001$. Through metabolic equivalent; the physical activity level of the subjects pre and post intervention was also calculated which was found to be statistically significant at <0.001.

- Among the 150 subjects who had metabolic syndrome, 52 of them had 3 metabolic syndrome criteria, 73 of them had 4 metabolic syndrome criteria and 25 of them had 5 metabolic syndrome criteria. All the subjects who had five criteria of the metabolic syndrome were having light physical activity. Subjects with metabolic syndrome 4 criteria had light physical activity and 9.6% were having sedentary activity. Subjects with metabolic syndrome 4 criteria (5.8%) had hard physical activity and 59.6% were having light physical activity. 34.6% of the subjects from metabolic syndrome 3 criteria were sedentary.

- From 150 participants in the three-month study period, 35 of them could come out of the metabolic syndrome state. From 25 subjects who had five metabolic syndrome criteria, only 10 remained in 5 metabolic syndrome criteria. The 73 subjects who had 4 metabolic syndrome criteria pre-intervention, were reduced to 48 subjects post-intervention. The pre- and post-metabolic syndrome criteria were having a highly significant correlation of <0 .001.

- The impact of lifestyle counselling on the KAP of the research subjects was analysed and found to be highly statistically significant ($p<0.001$).

- Post intervention results showed that the knowledge regarding good healthy diets/ general nutrition increased by 23% while the knowledge on benefits of exercise and weight loss knowledge was increased by 29% and knowledge regarding body composition increased by 57%. Knowledge regarding metabolic syndrome and lifestyle increased by 43% while the attitude and practice scores for lifestyle modifications increased by 16 and 37% respectively.

h) Papers Published

- Jyothsna, C.R., Kowsalya, S., & Raghu, J.S. (2023). Prevalence of Metabolic Syndrome Criteria among Adults Post Covid Pandemic Situation and Steps towards Prevention. *The Indian Journal of Nutrition and Dietetics*, 60 (1), 94-111.
- Jyothsna, C.R., & Kowsalya, S., (2021). Influence of Lifestyle Factors on Metabolic Syndrome Criteria. *The Indian Journal of Nutrition and Dietetics*, *58* (S1), 1–9. https://doi.org/10.21048/IJND.2021.58.S1.27532

i) Conclusion

From the above results, it was observed that metabolic syndrome prevalence in adults is increasing. It may be noted that the waist circumference is a valuable anthropometric measure that is to be monitored to prevent metabolic syndrome among individuals. Similarly, monitoring the body composition analysis parameters can help prevent the increase in metabolic syndrome cases. Nutrition education and emphasis on lifestyle adaptations like the inclusion of physical activity routine, cessation of smoking, and alcohol usage helped the subjects with metabolic syndrome. The lifestyle counselling given to the research subjects increased their knowledge regarding healthy diet/ lifestyle, exercise, healthy weight, body composition, and metabolic syndrome. It also helped subjects to develop a positive attitude and intention to practice a healthy lifestyle too.

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